Assessment of Biceps Brachii and Upper Trapezius Muscle Fatigue using EMG Measurements

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1. INTRODUCTION

Muscle fatigue is defined by S. Marthur et. al (2004) as a reduction in the force generating capacity of a muscle due to previous activity. Several other definitions suggest fatigue occurs when there are changes in EMG readings, or changes in perceived effort level for a given force level [6]. The presence of work-related musculoskeletal disorders (MSDs) including injuries of the back, trunk, upper extremities and lower extremities in automotive industrial employees is commonly recognised. According to Salvendy *et. al* (1997), the evidence that work-related chronic muscular skeletal disorders of the upper extremities is rapidly growing. Since most manual work requires the active use of the arms and hands, the structures of the upper extremity are particularly vulnerable to soft tissue injury.

Work-related upper extremity disorders are typically associated with repetitive manual tasks with forceful exertions, such as those performed at assembly lines. Repetitive manual tasks impose repeated stresses to the upper body, i.e the muscles, tendons, ligaments, nerves tissues and neurovascular structures. In this study, the possible risk of work-related musculoskeletal disorder to the upper extremity are tendon disorder such as tendonitis, nerve disorder such as Carpal tunnel syndrome, and neurovascular disorder such as thoracic outlet syndrome (Salvendy *et.al*, 1997).

A job that requires a worker to perform highly repetitive motions contributes to the onset of Cumulative Trauma Disorder (CTD) (Hymovich *et.al*,1966). Specifically, the more repetitive the task, the more rapid and frequent are the muscle contractions. Muscles that contract at high velocity develop less tension than those contracting at a slower velocity for the same load. Carpal tunnel syndrome appears to be induced more by the repetitiveness of the task rather than by the force levels (Armstrong, T.J *et al* 1983). Another research done by Luopajarni *et. al* (1979) on repetitions revealed that the prevalence of tenosynovitis and humeral tendonitis is significantly higher for workers who work at assembly lines.

In general, repetitive task in modern industry has proved to be debilitating for many millions of workers. It has also been proven to be one of the factors that could cause musculoskeletal disorders amongst correspondent workers. A pilot study was conducted to investigate the effect of task activity on biceps brachii and upper trapezius muscle response during repetitive task at a tyre assembly plant. The aim of the study is to determine the time before fatigue set in for both muscles in order to compare muscle activities during the repetitive work process. Thirty electromyography (EMG) measurements were taken from three selected samples at an assembly line involving the lifting of tyres. Measurements were taken for a duration of two and a half hours.

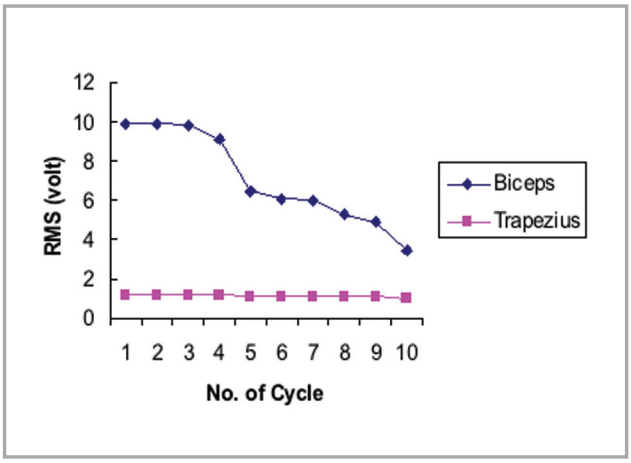

Figure 1: Sample 1

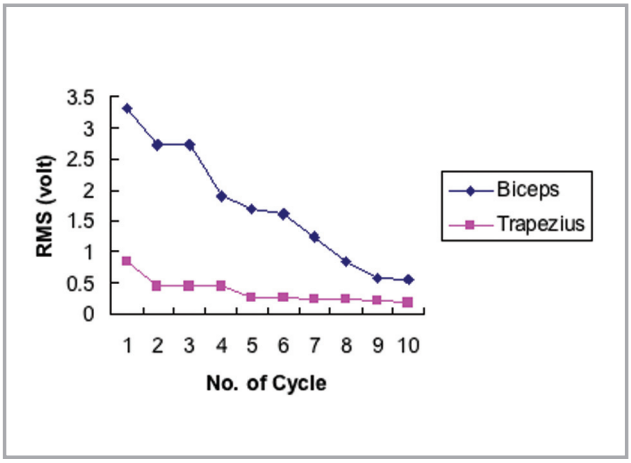

Figure 2: Sample 2

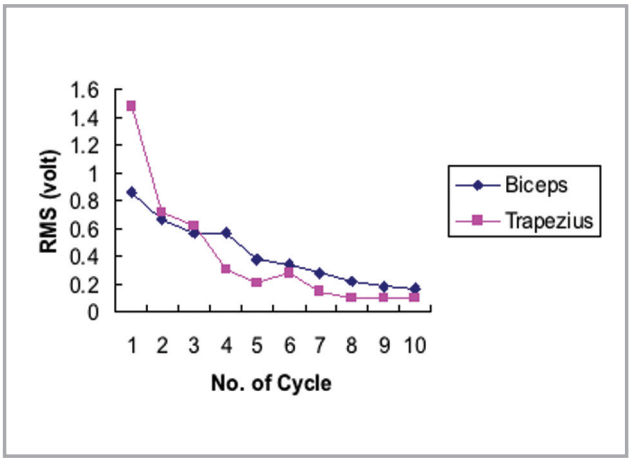

Figure 3: Sample 3

2. METHODS

2.1 Sample

Three sets of samples were selected from a tyre assembly plant for the study. This is a pilot study so the sample taken is small. The samples have no history of upper extremity complaints or other musculoskeletal problems.

2.2 Procedures

EMG surface electrodes were used to measure bicep brachii and trapezius muscles activity. Bicep brachii was selected because it is one of the primary muscles used in repetitive tasks at tyre assembly lines. Data were collected throughout the second job rotation within a two-and-a-half hour job duration. Ten measurements were taken for each sample within the duration. Electromyographiy recordings were obtained using the DataLab 2000 system.

2.3 Statistical Analysis

Regression analysis is carried out to examine the relationship between a dependant variable (time) and one independent variable. The following shows the general linear regression equation:

$$Y = \beta_0 + \beta_1 x + \in$$

3.0 RESULTS AND DISCUSSION

3.1 RMS Results

Figures 1, 2 and 3 show the RMS versus time for the three samples. The results indicate that the RMS measurements decrease with time which reflects the fatigue pattern for the task under study. It can be seen that the rate of fatigue obtained from each individual samples is varied and these could be the consequence of a change in muscle temperature [3] and difference in fibre types or differences in muscle fibre recruitment pattern [4].

The results show that the RMS decay overtime during sustained contraction and this is consistent with the literature of De Luca, 1984. It is also an indication that the fatigue time for trapezius muscles decrease more rapidly compared to biceps brachii muscles. This suggests that the lifting activities directly exercise the trapezius muscles more compared to biceps brachii muscles.

Table 1: Model summary of Trapezius muscle

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.858(a)	.736	.703	.238127960

Table 2: Model summary of Bicep Brachii Muscle

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.974(a)	.948	.942	.056256051

3.2 Regression Analysis on Biceps Brachii and Trapezius Muscles

Tables 1 and 2 summarised the regression analysis model for the three samples. The regression analysis R represents the absolute value of the correlation coefficient and to see how well the model fits a set of data, Pearson correlation R is most frequently used. In the models summary, R represents the absolute value of the correlation coefficient, where R square is the proportion of explained variability by squaring the correlation coefficient between the dependant variable, RMS and independent variable with time (R = 0.858 and 0.974). Adjusted R Square is an estimation of how well the model would fit another data set from the same population. For the R value, Adjusted R Square is preferable as it is more accurate. From Tables 2 and 3, the observed values are 0.703 and 0.942, which indicate that the linear regression model predicts well.

5.0 CONCLUSIONS

In summary, the conclusions derived from this investigation highlight that the time to fatigue for bicep brachii and trapezius muscles in repetitive work can be analysed and predicted. Further study will be conducted to determine the validity of the model with more samples and comparing with other muscles by applying the Regression model developed in this study for the muscles in order to predict fatigue with time. ■

REFERENCES

[1] Marthur S. *et. al*, Reliability of Surface EMG during sustained contractions of the quadriceps, Journal of Electromyography and Kinesolog, 15, 102-110, 2005.

[2] Salvendy, G. Handbook of Human Factors and Ergonomics. 2nd edition. John Wiley & Sons, 1997

[3] Duchene, J. and Goubel, F. Surface Electromyography during voluntary contraction processing tools and relation to physiological events, Crit. Rev. Biomed. Eng. 21, 313-397, 1993.

[4] Gerdle, B. Henriksson-Larsen, K, Lorentzon, R. and Wretling, M.L. Dependence of the main power frequency of the electromyogram on muscle force and fiber type, Acta Physiol, Scand. 142, 457-465, 1991.

[5] Kupa, E.J., Roy, S.H., Kandarian, S.C. and DeLuca, C.J. Effects of muscle fiber type and size on EMG median, frequency and conduction velocity, J. Appl. Phys. 79(1), 23-32, 1995.

[6] Esposito, F., Malgrati, D., Veicsteinas, A. and Orizio, C. Time and frequency domain analysis of electromyogram and sound myogram in the elderly, Eur. J. Appl. Physiol. 73, 503-510, 1996.

[7] Nagata, S., Arsenault, A.B., Gagnon, D., Smyth, G. and Mathieu, P.A. EMG power spectrum as a measure of muscular fatigue at different levels of contraction, Med. Biol. Eng. Comput. 28 (4), 374-378, 1990.

[8] Silverstein, B., Fine, L.J. and Armstrong, T.J. Hand wrist cumulative trauma disorders in industry, Brit. J. Ind. Med. 43, 779-784, 1986.